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COVER SHEET FOR TECHNICAL MEMORANDUM

TITLE- Addendum to TM-68-2032-1 [Analysis of Operations and Constraints Associated with the Mobile Service Structure (MSS) at Launch Complex 39]

TM- 69-2032-1

DATE- March 20, 1969

FILING CASE NO(S)- 320

AUTHOR(S)-G. J. McPherson Jr.

FILING SUBJECT(S)- (ASSIGNED BY AUTHOR(S))- Mobile Service Structure Constraints, Launch Pad Operations, Countdown, Scrub Turnaround

ABSTRACT

At the time the basic study was conducted, only Pad A and unmanned/non-LM countdown and scrub-turnaround data were available. Since then, Pad B and full-up Saturn V space vehicle data have been obtained. The intent of this memorandum is to supplement the referenced study such that together they will provide an up-to-date description and analysis of MSS operations and constraints at both, Pad A and Pad B.

This study concludes that:

a. Despite gains since the original study, the most significant constraints associated with MSS support of LC-39 continue to be the loss of SC access during the countdown and the delay in gaining SC access following a scrub decision.

b. The operations associated with the constraints of (a) above can be improved further only by elimination of the early open-loop SC A/G voice checks in the countdown and deletion of plywood installation during scrub turnaround.

c. MSS transfers between Pad B and the parksite require one hour longer than corresponding Pad A transfers. This is not currently a constraint on launch countdown or scrub-turnaround operations.

It is recommended that:

a. KSC assess the feasibility of retaining the MSS at the launch pad until T-9 hours 15 minutes.

b. KSC assess the feasibility of eliminating the plywood installation for scrub turnarounds.

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SUBJECT: Addendum to TM 68-2032-1 (Analysis of Operations and Constraints Associated with the Mobile Service Structure (MSS) at Launch Complex 39 Case 320

DATE: March 20, 1969

FROM: G. J. McPherson Jr. TM-69-2032-1

TECHNICAL MEMORANDUM

1.0 INTRODUCTION

Reference 1 described and analyzed the operations and constraints associated with the MSS at LC-39. It was based entirely upon Pad A data which primarily considered unmanned/non-LM countdown and scrub-turnaround operations. Data for Pad B and full-up/manned Saturn V operations has since become available.

The intent of this study is to supplement Reference 1 such that together they will provide an up-to-date description and analysis of MSS operations and constraints. Revised handling techniques are also presented which could lessen further the MSS constraints imposed upon LC-39.

Since much of the descriptive data contained in Reference 1 (particularly Appendix I) is currently accurate, only significant changes will be discussed herein.

The Pad B data has been acquired from actual transfer operations performed between the MSS parksite and Pad B. The full-up/manned countdown and scrub-turnaround data has been obtained through planning activities and operational experience associated with the preparation and launch of Apollo 5, 6, 7, 8, and 9.

The discussions and figures contained in this memorandum provide the following information:

1. a review of the significant conclusions and recommendations of Reference 1 --- (Section 2)

2. pertinent hardware and operational changes implemented since the original study --- (Sections 3 and 4)

3. current data associated with the movement of the MSS between the parksite and either pad during launch countdown and scrub-turnaround activities --- (Section 5)

4. an explanation and analysis of the current MSS move data --- (Section 5)

5. conclusions and recommendations --- (Sections 6 and 7)

6. acknowledgments and references.

2.0 REVIEW OF SIGNIFICANT CONCLUSIONS AND RECOMMENDATIONS

Reference 1 arrived at the following conclusions:

1. The most significant constraint imposed upon LC-39 by the MSS is delaying access to the SC following a scrub decision.

2. Modifications to MSS-related hardware and operational procedures would allow reduction in SC fluid servicing timelines.

3. The requirement to accomplish propellant "hot flows" as a part of MSS revalidation exercises jeopardizes the capability of KSC to meet the launch rates specified in APD-4H.

Based on the above conclusions, Reference 1 recommended:

1. That the MSS be returned to its pad position prior to commencing LV S&A device ordnance operations during scrub turnarounds

2. That KSC assess the benefits and tradeoffs involved with an even earlier MSS return

3. That KSC continue assessment of modifications which would reduce SC fluid servicing timelines

4. That KSC continue assessment of MSS revalidation requirements for possible deletion of the propellant "hot flows."

The following changes have since been implemented:

1. The MSS is now returned to its pad position much sooner following a scrub decision.

2. Modifications, both to procedures and hardware, have been made which allowed reduction to SC fluid servicing timelines.

3. Propellant "hot flows" have been eliminated from the MSS revalidation requirements.

The above changes as well as other pertinent hardware and procedural changes will be discussed in more detail in the subsequent sections.

3.0 HARDWARE CHANGES

3.1 SM CRYOGENIC SERVICING (LH_2)

Prior to Apollo 8, LH_2 servicing of the SM was accomplished by use of a pad-located mobile storage unit (S14-066) and associated Fluid Distribution System (FDS) components on various levels of the MSS. The new method (demonstrated on Apollo 8) involves use of a portable dewar unit (a modified SHe dewar), on MSS level 4A, which interfaces with the existing FDS plumbing. Although the mobile storage unit and the need to pump LH_2 from pad level were eliminated by this technique, much of the existing FDS is still utilized for purge, vent and drain operations.

The dewar method does not presently offer any benefits timewise, but should allow more reliable capacity loads. A second dewar unit, fully loaded, will be available for backup should the primary fail.

3.2 SM CRYOGENIC SERVICING (LO_2)

Although it was extremely desirable to implement a like capability for dewar servicing of SM LO_2, a modified SHe dewar unit loaded with sufficient LO_2 to provide mission load to the SM would have exceeded the allowable weight limits of both the MSS elevators and level 4A. A satisfactory dewar unit (weight-wise) has been procured and was utilized for the first time during Apollo 9 CDDT.

The dewar method was found to be satisfactory during CDDT and was subsequently implemented for the Apollo 9 launch countdown. A second LO_2 dewar unit has been provided as a ready backup should the primary unit fail.

It is anticipated that the LO_2 dewars will become the accepted method for LO_2 servicing of all future CSM's. Deletion of certain GSE (LO_2 mobile storage unit, etc.,) will probably become effective prior to servicing Apollo 10.

4.0 OPERATIONAL CHANGES

4.1 Launch Countdown

4.1.1 Connection of S&A Devices

Reference 1 concluded that an earlier return of the MSS to the pad during scrub-turnaround operations would result in shorter scrub turnarounds by providing access to the SC servicing locations significantly sooner than previously possible. Although Reference 1 also included a suggested technique for accomplishing the earlier return, benefits were less than optimum because of a requirement to clear personnel from the MSS during S&A device ordnance operations. This same clearance requirement was also identified as the prime constraint for determining how late the MSS could be retained at the launch pad during the launch countdown.

Realizing that the above clearance criterion constrained key activities during both launch countdown and scrub-turnaround operations, KSC initiated efforts to re-examine the hazard levels involved with S&A ordnance operations and to revise the clearance criterion accordingly. An independent study (Reference 2) had also been initiated not only to assess the hazard levels associated with S&A device ordnance operations, but also to examine those related to the final DRSCS receiver checks during the launch countdown.

The original clearance criterion required that the MSS (if personnel were aboard) be no closer than the 35-foot point during all S&A device ordnance operations; connection during the launch countdown and disconnection/exchange during scrub turnarounds.

Both the KSC Safety assessment and Reference 2 concluded that although the ordnance involved does present a potential hazard to nearby personnel, the connection/disconnection operations did not increase the hazard level nor the probability of its detonation in a mode which would endanger nearby personnel.

The clearance criterion was revised for both the connection (countdown) and disconnection/exchange (scrub turnaround) operations to require clearance of personnel from within all SV interior locations below the SM level. The revised criterion resulted in the capability to retain the MSS at the launch pad later in the countdown, hence, allowing later servicing of the SC.

The current constraint for determining how late the MSS can be retained at the pad during the launch countdown will be discussed in Section 5 and Appendix I.

4.1.2 Personnel Access on LUT and in SV During MSS Movement

KSC Safety criterion previously required that personnel clear the LUT S/A's and the SV interior during MSS jacking; also, during MSS transfer operations whenever the MSS is within 35 feet of the SV.

The clearance requirement has since been reassessed and revised to allow personnel to continue working in both locations during the respective MSS operations in both the launch countdown and scrub turnaround.

4.2 Scrub Turnaround

4.2.1 Installation and Soaping of Plywood

A significant constraint not identified in Reference 1 concerns the requirement to install some 300 sheets of plywood on the pad surface where critical C/T (crawler/transporter) maneuvering is necessary to accurately position the MSS prior to jackdown. The plywood sheets are first secured in position by wedges and then thoroughly wetted with a thick soap solution. This provides an appreciable reduction in surface friction and, hence, the required C/T maneuverability.

Since the MSS can essentially be ready to roll through the pad gate (required distance prior to completion of the safety inspection) by the time the safety inspection is complete, and requires less than 45 minutes to reach its pad position, the two-hour plywood installation function will always be the constraining activity. The effect of this will be discussed in Section 5 and Appendix I.

4.2.2 LUT and SV Access During MSS Movement

(See Section 4.1.2)

4.2.3 Disconnection of S&A Devices

(See Section 4.1.1)

The current constraints for determining how soon the MSS can be returned to the launch pad during scrub-turn-around operations will be discussed in Section 5 and Appendix I.

5.0 CURRENT MSS CONSTRAINTS AND DATA

5.1 Constraint of MSS Movement

5.1.1 Launch Countdown

At the time Reference 1 was written, MSS departure during the launch countdown was chosen to allow just enough time for the MSS to be beyond the 35-foot point for S&A device connection. With the elimination of this constraint, MSS departure time is now keyed to the next most constraining event; SC air-to-ground open-loop voice checks.

The SC A/G voice checks require personnel participation in the CM and presently require the MSS to be out of the RF line-of-sight during the checks. Since final pad clearing must commence by T-9 hours to provide adequate time for LV cryogenic servicing, the SC A/G voice checks must start no later than T-9 hours 30 minutes. To assure that the MSS is out of the RF line-of-sight by this time and also that the MSS is outside the perimeter fence by T-9 hours, the MSS must start moving toward the parksite by T-10 hours 15 minutes.

Retaining the MSS at the launch pad as late as T-10 hours 15 minutes has allowed access to SC servicing locations some 2 1/2 hours later in the launch countdown than was previously possible.

Additional discussion concerning the advantages and tradeoffs involved with retaining the MSS at the launch pad even later in the countdown will be found in Appendix I, Section A.I.13

5.1.2 Scrub Turnaround

Reference 1 revealed that return of the MSS to the launch pad subsequent to a scrub decision was constrained by S&A device disconnection which required the MSS to remain beyond the 35-foot point until completed. With the elimination of this constraint, MSS return would have been keyed to the completion of the safety inspection were it not for the recent identification of the plywood constraint.

Since the plywood installation crew as well as the MSS must wait outside the pad gate until the safety inspection is completed, both activities will generally start at about the same time. Installing and soaping the plywood requires two hours; return of the MSS from the 1350-foot point requires less than 45 minutes.

Despite identification of the plywood constraint, elimination of the S&A ordnance constraint has allowed earlier return of the MSS and access to SC servicing locations some 2 to 3 hours sooner than previously possible.

Additional discussion concerning the possibility of deleting the use of plywood during scrub turnarounds will be found in Appendix I, Section A.I.14.

5.2 Current MSS Data

Similar to Reference 1, the current MSS data is best presented in the form of figures. Some 14 figures have been prepared which replace or supplement those of the original study.

The examination, explanation, and analysis of the figures is contained in Appendix I. Included are potential techniques for further reducing MSS constraints levied on LC-39 operations.

5.3 Recent LV Cryogenic Timeline Revisions

5.3.1 Loading Sequence

Subsequent to the launch of Apollo 8, a revision to the LV cryogenic servicing timeline was proposed by KSC LVO. The revision involved starting the LO_2 facility chill-down function 15 minutes earlier. This would ensure that LV cryogenic servicing would complete in time for the SC closeout crew to depart the MSS parksite at T-3 hours 25 minutes.

The proposal was accepted and has since been implemented on Apollo 9. Although the revised loading timeline changes slightly the data and figures presented herein, it was considered relevant to update Figures 2 and 13, only.

The revised times for LV cryogenic servicing milestones are presented here, however, for reference purposes along with those used for this study.

TIMES USED FOR THIS STUDY	LV CRYO CONFIGURATION	REVISED TIMES
Between T-8H 0M and T-6H 27M	Start chilldown S-IVB 100% LO_2 Load S-II 100% LO_2 Load Start S-IC LO_2 Load	Between T-8H 15M and T-6H 32M
T-4H 57M	S-IC 100% LO_2 Load	T-5H 7M
T-4H 11M	S-II 100% LH_2 Load	T-4H 21M
T-3H 28M	S-IVB 100% LH_2 Load	T-3H 38M

5.3.2 Unloading Sequence

The LV cryogenic unload timeline was also recently revised by KSC to correct a 15-minute error in total unload time. The corrected timeline includes 15 minutes of drain preparations (S/A #1 and primary damper reconnection) prior to actual drain activities.

Since the error does not affect the overall results of this study but only the accuracy of select data in the figures, the correction was not incorporated en toto but only in Figure 3.

The corrected times for LV cryogenic drain milestones are presented here, for reference purposes only, along with those used for this study.

TIMES USED FOR THIS STUDY	LV CRYO CONFIGURATION	CORRECTED TIMES
S + 1H 0M	LV ready to start drain	S + 1H 15M
S + 1H 45M	S-IVB LH_2 drained	S + 2H 0M
S + 2H 30M	S-II LH_2 drained	S + 2H 45M
S + 3H 5M	S-IVB LO_2 drained	S + 3H 20M
S + 3H 15M	S-II LO_2 drained	S + 3H 30M
S + 5H 15M	S-IC LO_2 drained	S + 5H 30M
S + 6H 15M	Safety inspection complete	S + 6H 30M

6.0 CONCLUSIONS

The following conclusions are applicable to both Pad A and Pad B unless otherwise noted.

1. The revised clearance criteria used during S&A device ordnance operations and MSS movements near the SV have essentially eliminated the MSS constraints previously identified relative to these operations.

2. Deletion of the MSS "hot flows" as part of the MSS revalidation criteria has eliminated the need to return the MSS to a launch pad prior to its move in support of the subsequent SV's pad processing. The MSS can now be ready to support a new SV almost immediately following a launch event.

3. Despite gains since Reference 1 was written, the most significant constraints associated with MSS support of LC-39 continue to be:

   a. the loss of access to SC servicing locations as the MSS is prepared for its move during the launch countdown

   b. the delay in gaining access to SC servicing locations subsequent to a scrub decision

4. Pad operations related to the constraints of conclusion 3 above are at present, optimized and can be improved further only by eliminating the early SC A/G voice checks in the launch countdown and the plywood installation during scrub turnaround.

5. MSS transfers between Pad B and the parksite require one hour longer than corresponding transfers between Pad A and the parksite. The longer travel time does not prove to be a constraint to the current countdown since adequate time exists to accommodate the longer move. Similarly for scrub turnarounds, the longer time does not prove to be a constraint at present since the delay for plywood installation exceeds the additional move time.

7.0 RECOMMENDATIONS

1. KSC assess the feasibility of retaining the MSS at the launch pad until T-9 hours 15 minutes as described in Appendix I, Section A.I.13.

2. KSC assess the feasibility of eliminating the plywood installation for MSS returns in support of scrub-turnaround operations as described in Appendix I, Section A.I.14.

8.0 ACKNOWLEDGMENTS

The information contained herein as well as in Reference 1 was acquired through extremely cooperative efforts by personnel of various KSC and KSC contractor organizations. The author expresses his appreciation for the timeliness and completeness of the data provided to him.

G. J. McPherson Jr.

2032-GJM-mp

Attachments
Figures 1-14
Appendix I

References

1. Analysis of Operations and Constraints Associated with the Mobile Service Structure (MSS) at Launch Complex 39 - Case 320, Bellcomm Technical Memorandum, TM-68-2032-1, G. J. McPherson Jr., dated May 8, 1968.

2. Range Safety System Operations During Saturn V Countdowns - Case 320, Bellcomm Memorandum for File, G. J. McPherson Jr., dated August 14, 1968.

3. Actual Timelines for MSS Movement - Parksite to Pad B and Return, in form of data sheet provided by Bendix Transporter Section (Messr. E. Walsh), no date.

4. Crawler/Transporter Trip Chart, 67-K-L-12199, Bendix, Basic - dated October 24, 1967.

5. AS-504 SV Countdown Test Processing Bar Chart, KSC, Rev. 003, dated February 10, 1969.

6. Apollo/Saturn V Space Vehicle Scrub/Turnaround Plan (Apollo 8) SA-503/CSM 103, KSC 630-39-0035, dated December 2, 1968.

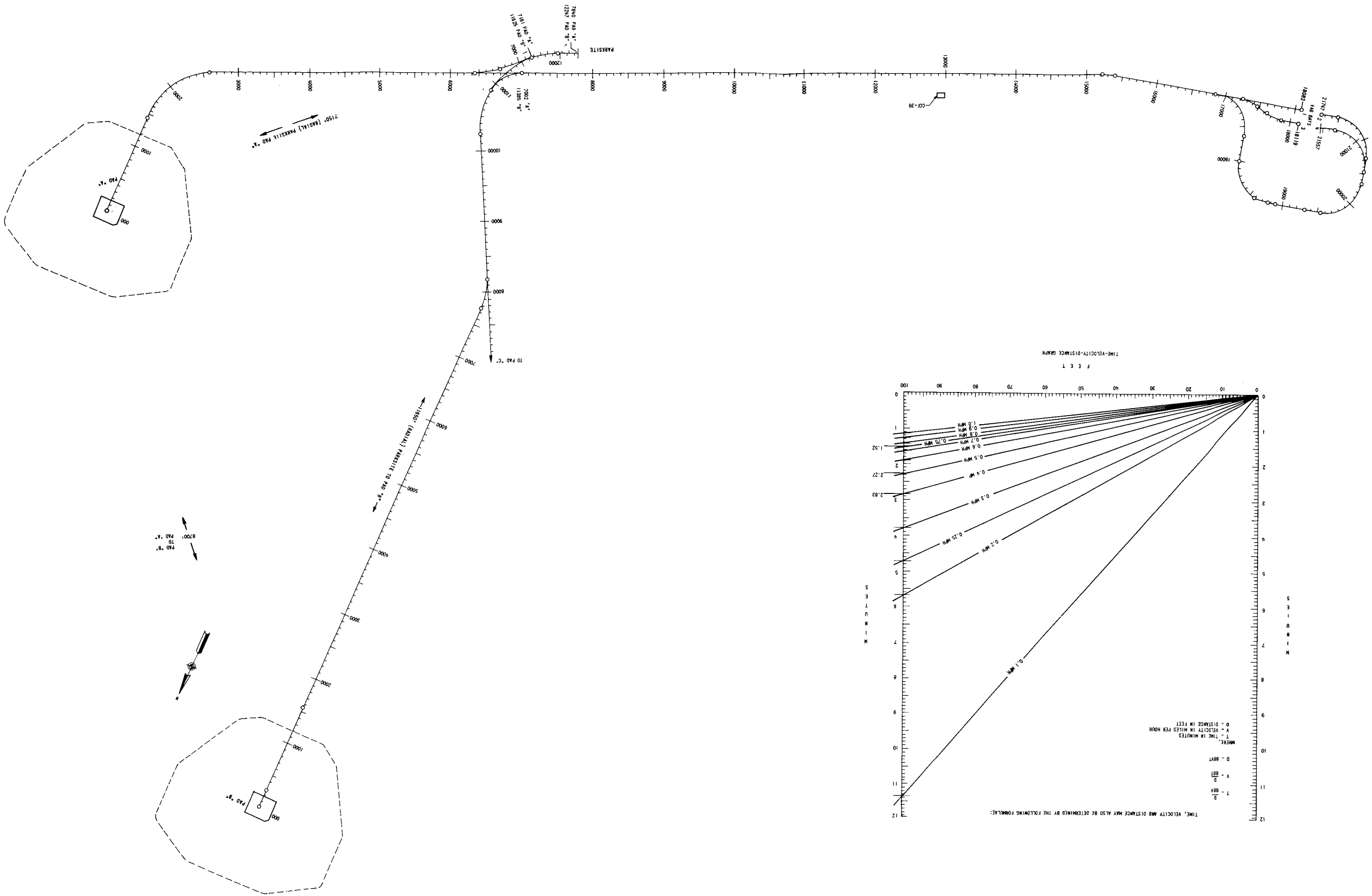
7. Apollo/Saturn V Launch Mission Rules Apollo 9 (SA-504/CSM 104/LM-3) KSC K-V-05.10/4, Final - dated February 3, 1969.

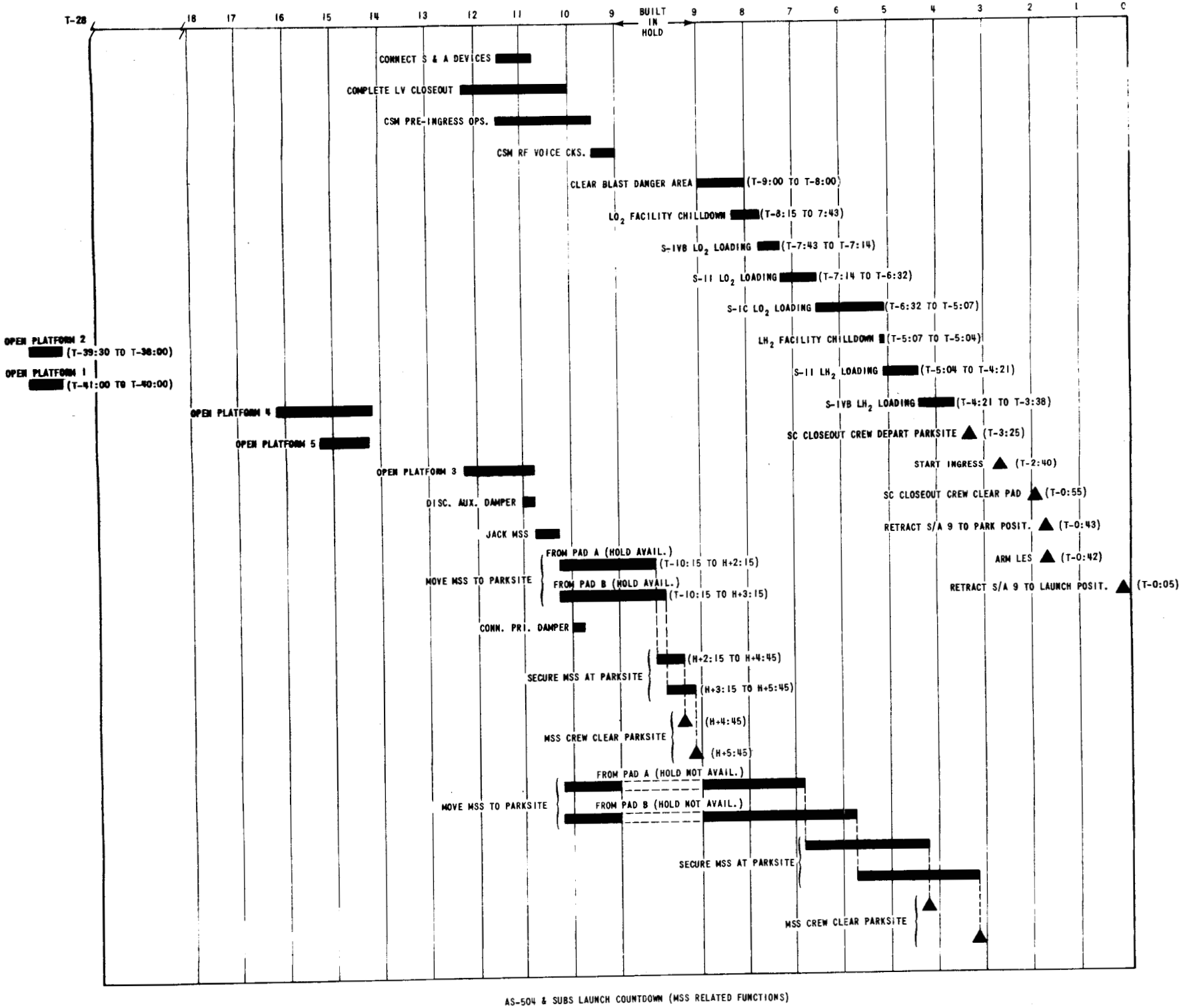
8. Apollo/Saturn V Ground Safety Plan, Vol. II, KSC K-V-053, Revision 2, dated January 1, 1969.

9. Saturn V Propellant Loading Chart, Page 7-1, V. 35014, AS-504, KSC, date unknown.

10. Apollo/Saturn V Space Vehicle Scrub/Turnaround Plan, Apollo 9, SA-504/CSM-104/LM-3, KSC 630-39-0037, dated January 23, 1969.

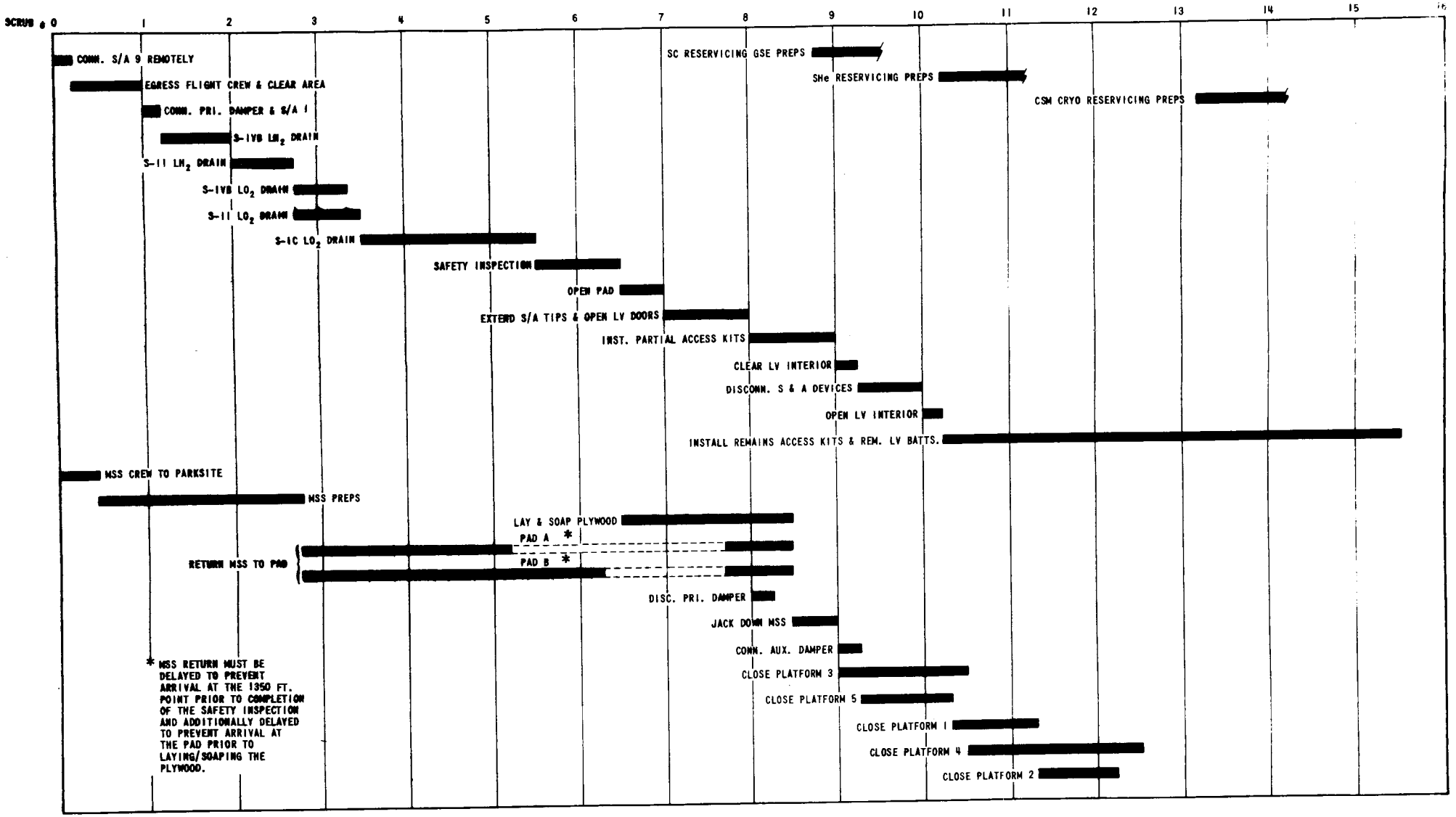
LC-39 CRAWLER TRANSPORTER GROUND TRACK
FIGURE 1





AS-504 & SUBS LAUNCH COUNTDOWN (MSS RELATED FUNCTIONS)

FIGURE NO. 2 -



AS-504 & SUBS SCRUB TURNAROUND PREREQUISITES (MSS RELATED)

FIGURE NO. 3

		READ DOWN			READ UP		
RADIAL DISTANCE (FEET)	TRAVEL DISTANCE (FEET)	CALCULATED RUNNING TIME PAD A TO PARKSITE	REMARKS	SPEED (MPH)	CALCULATED RUNNING TIME PARKSITE TO PAD A	REMARKS	SPEED (MPH)
AT PAD (JACKED UP)	AT PAD (JACKED UP)	0H 0M	SEE NOTES 1 & 2		2H 49M	OVER MOUNTS	
				0.10			0.10
35	35	0H 5M	START DOWN RAMP		2H 44M	SEE NOTE 3	
850	850	0H 45M	ON RAMP	0.25	2H 23M	ON RAMP	0.40
1,350	1,350	1H 9M	END OF RAMP START CURVE		2H 11M	END CURVE START UP RAMP	
2,500	2,650	1H 39M	END CURVE START STRAIGHTAWAY	0.50	1H 41M	END STRAIGHTAWAY START CURVE	0.50
2,650	2,900	1H 43M	STRAIGHTAWAY		1H 37M	STRAIGHTAWAY	
3,200	3,650	1H 54M			1H 26M		
3,600	4,130	2H 0M			1H 20M		
4,200	4,800	2H 10M		0.75	1H 10M		0.75
4,600	5,290	2H 16M			1H 2M		
4,800	5,490	2H 19M	STRAIGHTAWAY		0H 59M	STRAIGHTAWAY	
5,530	6,300	2H 37M	END STRAIGHTAWAY START CURVE		0H 47M	END CURVE START STRAIGHTAWAY	
				0.50 SEE NOTE 4			0.50 SEE NOTE 4
7,150	7,850	3H 18M	OVER MOUNTS		0H 0M	AT PARKSITE (JACKED UP)	

NOTE 1: DOES NOT INCLUDE TIME FOR SAFETY CLEARANCE
NOTE 2: DOES NOT INCLUDE TIME FOR COMM. (REQUEST/RESPOND)
NOTE 3: DOES NOT INCLUDE TIME FOR MOUNT OBSERVER COMM. CKS.
NOTE 4: SPEED IS REDUCED TO BELOW 0.1 MPH WITHIN 100-150 FEET OF PARKSITE

MSS TRANSFER BETWEEN PAD A AND PARKSITE
FIGURE NO. 4

LV CRYO CONFIGURATION	MSS REQUIRED DISTANCE FROM PAD A		COUNTDOWN		SCRUB	
	RADIAL	TRAVEL	NOMINAL "T" TIME OF LV LOAD	LATEST "T" TIME MSS CAN DEPART PAD A	NOMINAL SCRUB TIME OF LV UNLOAD	EARLIEST "S" TIME MSS CAN DEPART PARKSITE
START CHILLDOWN S-IVB 100% LO_2 LOAD S-II 100% LO_2 LOAD START S-IC LO_2 LOAD	850 FT.	850 FT.	BETWEEN T-8H 0M AND T-6H 27M	T-8H 45M	S+5H 15M	S+2H 52M
S-IC 33% LO_2 LOAD	2650 FT.	2900 FT.	T-5H 33M	T-7H 16M	S+4H 35M	S+2H 58M
S-IC 66% LO_2 LOAD	3200 FT.	3650 FT.	T-5H 15M	T-7H 9M	S+3H 55M	S+2H 29M
S-IC 100% LO_2 LOAD	3600 FT.	4130 FT.	T-4H 57M	T-6H 57M	S+2H 30M	S+1H 10M
S-II 50% LH_2 LOAD	4200 FT.	4800 FT.	T-4H 30M	T-6H 40M	S+2H 8M	S+0H 58M
S-II 100% LH_2 LOAD	4600 FT.	5250 FT.	T-4H 11M	T-6H 27M	S+1H 45M	S+0H 42M
S-IVB 50% LH_2 LOAD	4700 FT	5370 FT.	T-3H 47M	T-6H 4M	S+1H 30M	S+0H 30M
S-IVB 100% LH_2 LOAD	4800 FT.	5490 FT.	T-3H 28M	T-5H 47M	S+1H 0M	S+0H 1M
NOTE: THE "T" TIMES ARE BASED ON AS-503 & SUBS MANNED MISSION COUNTDOWN & SCRUB-TURNAROUND PLANNING						

MSS REQUIRED DISTANCES (PERSONNEL SAFETY) FROM PAD A FOR HAZARDOUS LV PROPELLANT CONFIGURATIONS

FIGURE NO. 5

		READ DOWN			READ UP		
RADIAL DISTANCE (FEET)	TRAVEL DISTANCE (FEET)	CALCULATED RUNNING TIME PAD B TO PARKSITE	REMARKS	SPEED (MPH)	CALCULATED RUNNING TIME PARKSITE TO PAD B	REMARKS	SPEED (MPH)
AT PAD (JACKED UP)	AT PAD (JACKED UP)	0H 0M	SEE NOTES 1 & 2		3H 54M	OVER MOUNTS	
				0.10			0.10
35	35	0H 5M	START DOWN RAMP		3H 49M	SEE NOTE 3	
850	850	0H 45M	ON RAMP	0.25	3H 28M	ON RAMP	0.40
1,350	1,350	1H 9M	END OF RAMP		3H 15M	START UP RAMP	
2,650	2,650	1H 29M	STRAIGHTAWAY		2H 55M	STRAIGHTAWAY	
3,200	3,200	1H 37M			2H 47M		
3,600	3,600	1H 42M			2H 42M		
4,200	4,200	1H 51M		0.75	2H 33M		0.75
4,600	4,600	1H 57M			2H 27M		
4,800	4,800	2H 0M	STRAIGHTAWAY		2H 24M	STRAIGHTAWAY	
7,750	7,750	2H 45M	END STRAIGHTAWAY START CURVE		1H 39M	END CURVE START STRAIGHTAWAY	
				0.50			0.50
8,190	8,200	2H 55M	END CURVE START STRAIGHTAWAY		1H 29M	END STRAIGHTAWAY START CURVE	
				0.75			0.75
9,990	10,250	3H 26M	END STRAIGHTAWAY START CURVE		0H 58M	END CURVE START STRAIGHTAWAY	
				0.50 SEE NOTE 4			0.50 SEE NOTE 4
11,650	12,250	4H 24M	OVER MOUNTS		0H 0M	AT PARKSITE (JACKED UP)	

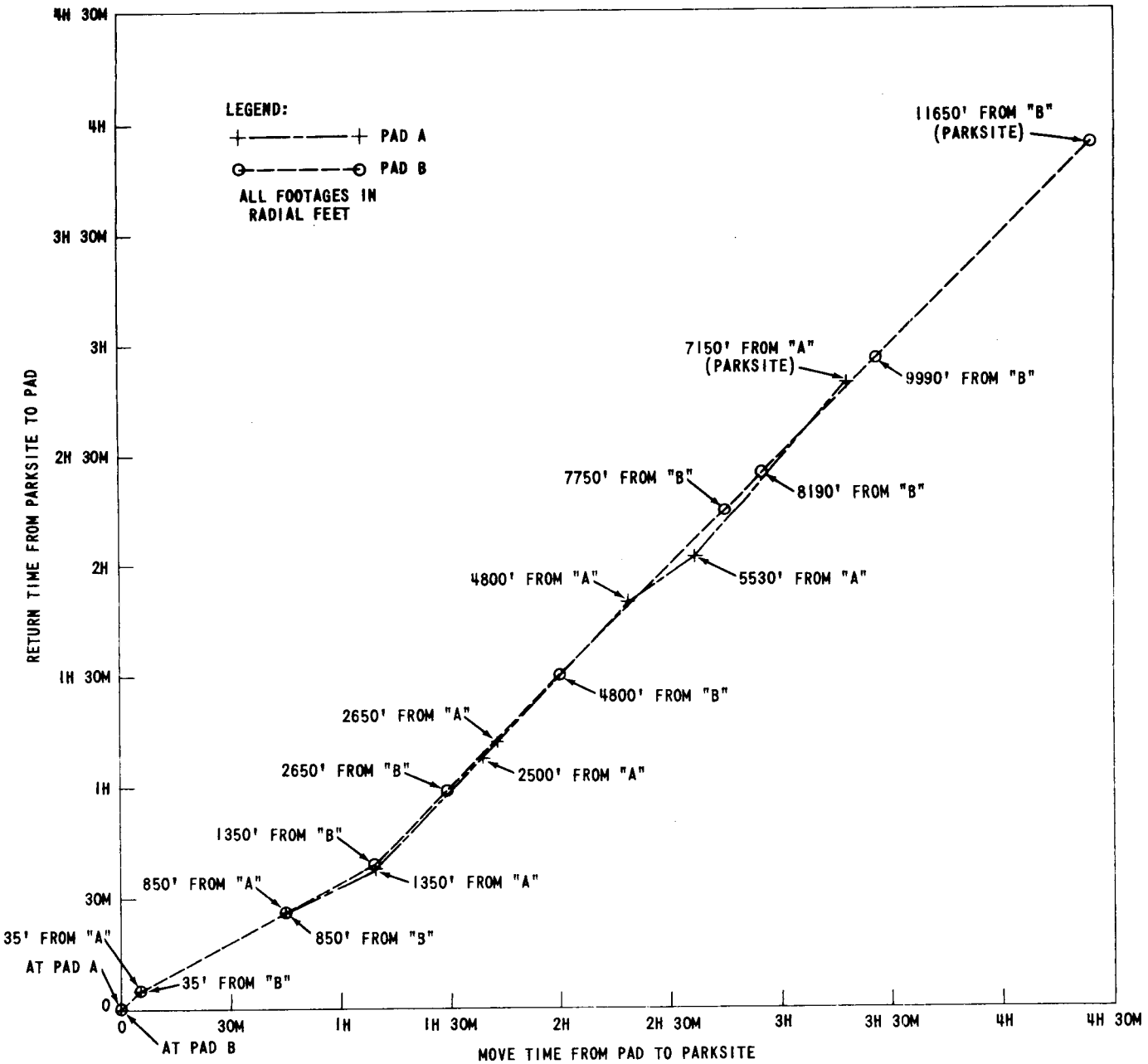
NOTE 1: DOES NOT INCLUDE TIME FOR SAFETY CLEARANCE
NOTE 2: DOES NOT INCLUDE TIME FOR COMM. (REQUEST/RESPOND)
NOTE 3: DOES NOT INCLUDE TIME FOR MOUNT OBSERVER COMM. CKS.
NOTE 4: SPEED IS REDUCED TO BELOW 0.1 MPH WITHIN 100-150 FEET OF PARKSITE

MSS TRANSFER BETWEEN PAD B AND PARKSITE
FIGURE NO. 6

LV CRYO CONFIGURATION	MSS REQUIRED DISTANCE FROM PAD B		COUNTDOWN		SCRUB	
	RADIAL	TRAVEL	NOMINAL "T" TIME OF LV LOAD	LATEST "T" TIME MSS CAN DEPART PAD B	NOMINAL SCRUB TIME OF LV UNLOAD	EARLIEST "S" TIME MSS CAN DEPART PARKSITE
START CHILLDOWN S-IVB 100% LO_2 LOAD S-II 100% LO_2 LOAD START S-IC LO_2 LOAD	850 FT.	850 FT.	BETWEEN T-8H 0M AND T-6H 27M	T-8H 45M	S+5H 15M	S+1H 47M
S-IC 33% LO_2 LOAD	2650 FT.	2650 FT.	T-5H 33M	T-7H 2M	S+4H 35M	S+1H 40M
S-IC 66% LO_2 LOAD	3200 FT.	3200 FT.	T-5H 15M	T-6H 52M	S+3H 55M	S+1H 8M
S-IC 100% LO_2 LOAD	3600 FT.	3600 FT.	T-4H 57M	T-6H 39M	S+2H 30M	S-0H 12M
S-II 50% LH_2 LOAD	4200 FT.	4200 FT.	T-4H 30M	T-6H 21M	S+2H 8M	S-0H 25M
S-II 100% LH_2 LOAD	4600 FT.	4600 FT.	T-4H 11M	T-6H 8M	S+1H 45M	S-0H 42M
S-IVB 50% LH_2 LOAD	4700 FT	4700 FT.	T-3H 47M	T-5H 45M	S+1H 30M	S-0H 55M
S-IVB 100% LH_2 LOAD	4800 FT.	4800 FT.	T-3H 28M	T-5H 28M	S+1H 0M	S-1H 24M
NOTE: THE "T" TIMES ARE BASED ON AS-503 & SUBS MANNED MISSION COUNTDOWN & SCRUB-TURNAROUND PLANNING						

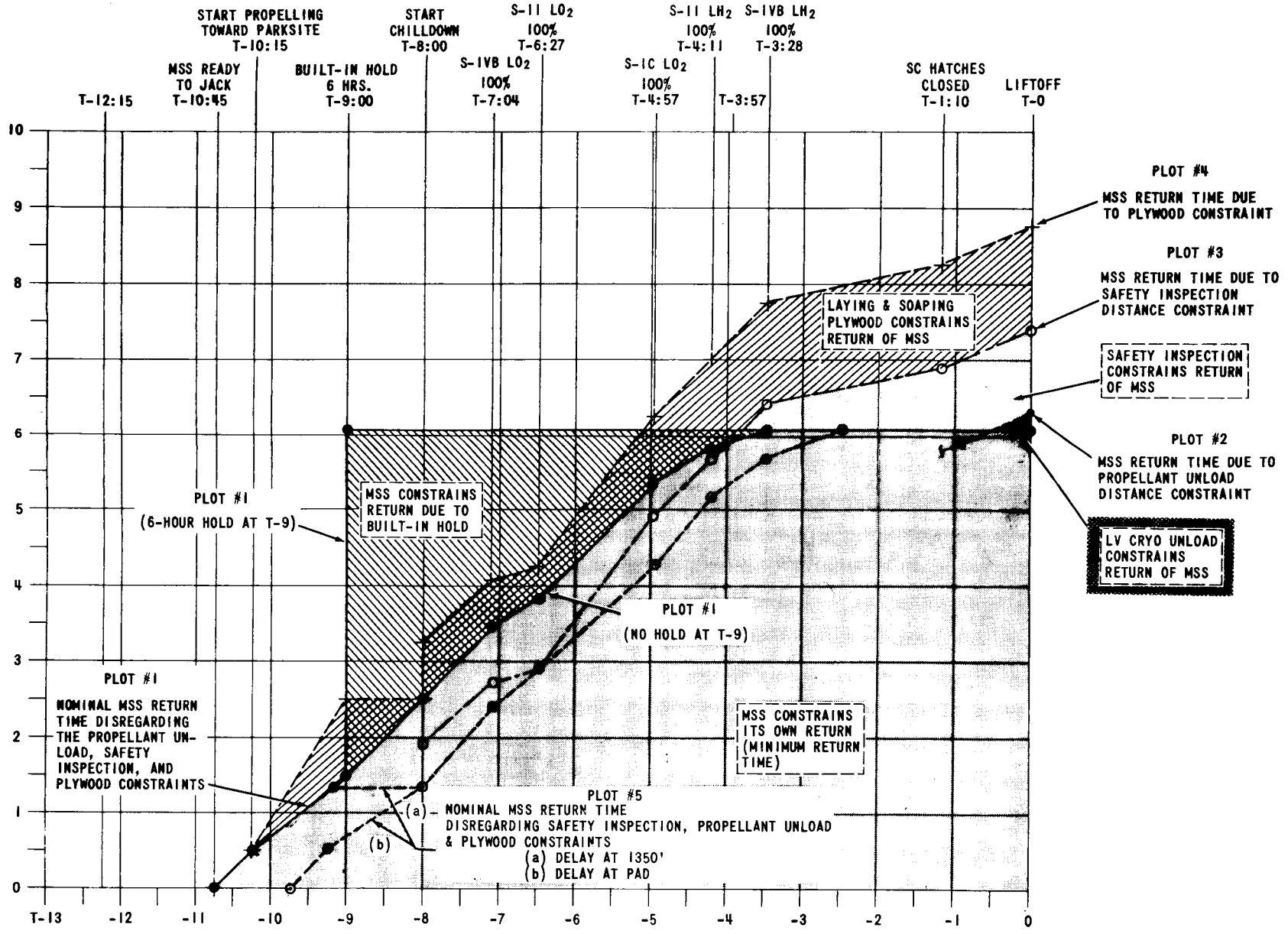
MSS REQUIRED DISTANCES (PERSONNEL SAFETY) FROM PAD B FOR HAZARDOUS LV PROPELLANT CONFIGURATIONS

FIGURE NO. 7



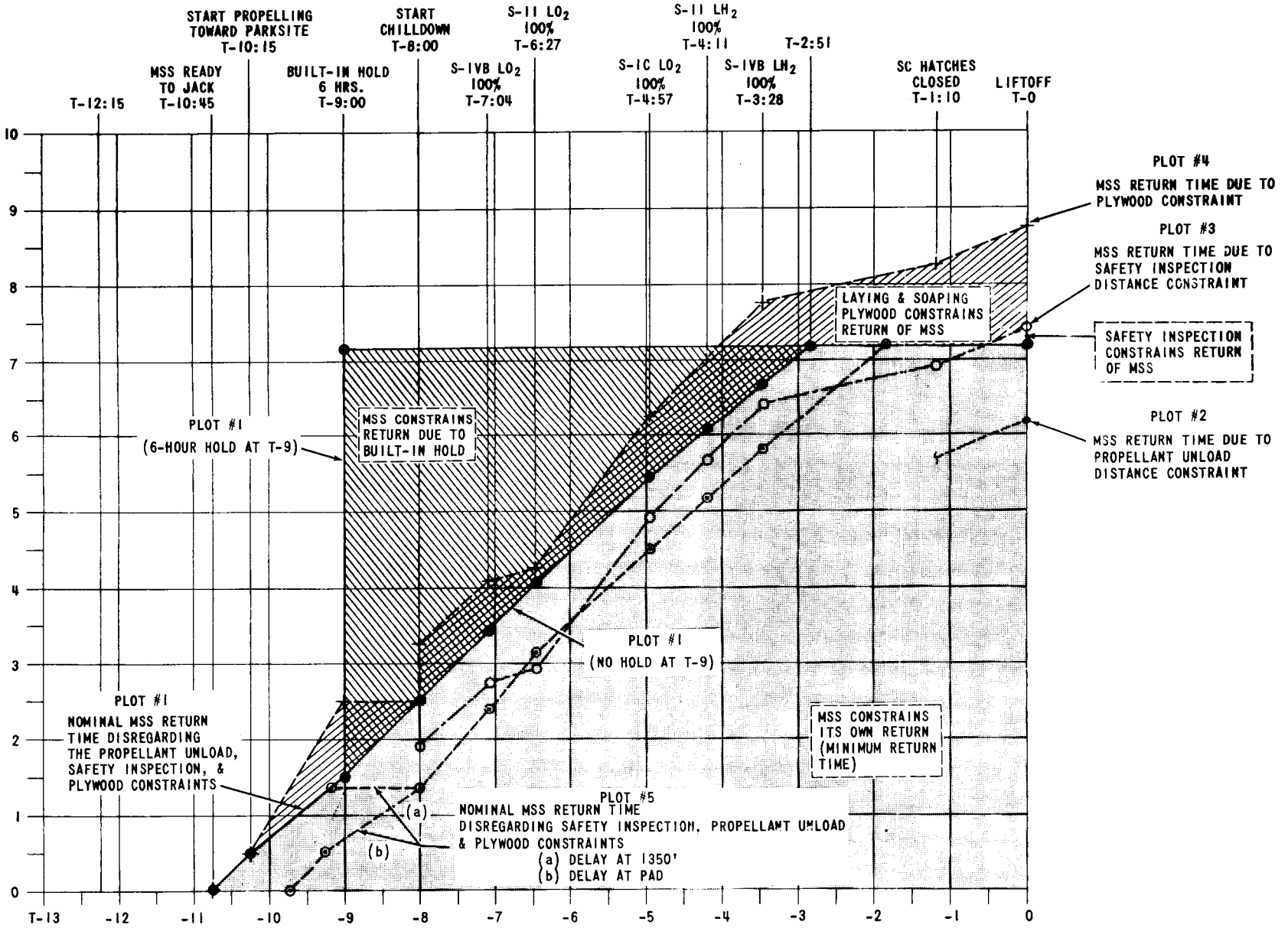
MSS MOVE & RETURN TIMES BETWEEN PAD AND PARKSITE

FIGURE NO. 8



MSS RETURN TIME (PAD A) VS. "T" TIME OF SCRUB DECISION

FIGURE NO. 9



MSS RETURN TIME (PAD B) VS. "T" TIME OF SCRUB DECISION

FIGURE NO. 10

LV CONFIGURATION		MINIMUM DISTANCE CONSTRAINT (RADIAL FEET)	SCRUB AT T-8:00 (PRIOR TO START OF CHILLDOWN)				SCRUB AT T-8:00 (JUST AFTER START OF CHILLDOWN)				SCRUB AT T-7:04			
			LV UNLOADED AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)	MSS ARRIVES AT PAD AT SCRUB PLUS (HR:MIN)		LV UNLOADED AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)	MSS ARRIVES AT MINIMUM DIST. CONSTR. AT SCRUB PLUS (HR:MIN)		LV UNLOADED AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)	MSS ARRIVES AT MINIMUM DIST. CONSTR. AT SCRUB PLUS (HR:MIN)	
				PADS A&B	PAD A	PAD B		PADS A&B	PAD A	PAD B		PADS A&B	PAD A	PAD B
CHILLDOWN		850	0:00	0:15	2:16*	2:15*	0:00	0:15	1:35	1:34				
S-IVB LH_2	100%	4800												
	50%	4700												
	0%	4600												
S-II LH_2	100%	4600												
	50%	4200												
	0%	3600												
S-IVB LO_2	100%	850									0:00	0:15	2:38	3:04
	50%	850									0:17	0:15	2:38	3:04
	0%	850									0:35	0:15	2:38	3:04
S-II LO_2	100%	850												
	50%	850												
	0%	850												
S-IC LO_2	100%	3600												
	66%	3200												
	33%	2650												
	0%	850												

	MINIMUM DISTANCE CONSTRAINT (RADIAL FEET)	SAFETY INSPECTION COMPLETE AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)	MSS ARRIVES AT PAD AT SCRUB PLUS (HR:MIN)		SAFETY INSPECTION COMPLETE AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)	MSS ARRIVES AT SAFETY INSP. CONST. DIST. AT SCRUB PLUS (HR:MIN)		SAFETY INSPECTION COMPLETE AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)	MSS ARRIVES AT SAFETY INSP. CONST. DIST. AT SCRUB PLUS (HR:MIN)	
			PADS A&B	PAD A	PAD B		PADS A&B	PAD A	PAD B		PADS A&B	PAD A	PAD B
SAFETY INSPECTION	1350	0:00	0:15	2:16*	2:15*	0:45	0:15	1:23	1:21	1:35	0:15	2:26	2:42

*INCLUDES JACKDOWN

DATA SHEET FOR PLOTS I-

FIGURE NO.

SCRUB AT T-6:27					SCRUB AT T-4:57					SCRUB AT T-4:11					SCRUB AT T-3:28					SCRUB AT T-0			
ADED RUB S N)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)		MSS ARRIVES AT MINIMUM DIST.CONSTR. AT SCRUB PLUS (HR:MIN)		LV UNLOADED AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)		MSS ARRIVES AT MINIMUM DIST.CONSTR. AT SCRUB PLUS (HR:MIN)		LV UNLOADED AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)		MSS ARRIVES AT MINIMUM DIST.CONSTR. AT SCRUB PLUS (HR:MIN)		LV UNLOADED AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)		MSS ARRIVES AT MINIMUM DIST.CONSTR. AT SCRUB PLUS (HR:MIN)		LV UNLOADED AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)	MSS ARRIVES AT MINIMUM DIST.CONSTR. AT SCRUB PLUS (HR:MIN)	
	PAD A	PAD B	PAD A	PAD B		PAD A	PAD B	PAD A	PAD B		PAD A	PAD B	PAD A	PAD B		PAD A	PAD B	PAD A	PAD B		PADS A&B	PAD A	PAD B
															0:00	2:45	2:15	3:44	4:39	1:00	2:45	3:44	5:09
															0:30	2:45	2:15	3:45	4:40	1:30	2:45	3:45	5:10
															0:45	2:45	2:15	3:47	4:42	1:45	2:45	3:47	5:12
										0:00	2:30	1:40	3:32	4:07	0:45	2:45	2:15	3:47	4:42	1:45	2:45	3:47	5:12
										0:23	2:30	1:40	3:40	4:13	1:08	2:45	2:15	3:55	4:48	2:08	2:45	3:55	5:18
										0:45	2:30	1:40	3:50	4:22	1:30	2:45	2:15	4:05	4:57	2:30	2:45	4:05	5:27
0	0:30	0:15	2:53	3:17	0:00	2:00	1:00	4:23	4:28	0:45	2:30	1:40	4:53	5:08	1:30	2:45	2:15	5:08	5:43	2:30	2:45	5:08	6:13
7	0:30	0:15	2:53	3:17	0:17	2:00	1:00	4:23	4:28	1:02	2:30	1:40	4:53	5:08	1:47	2:45	2:15	5:08	5:43	2:47	2:45	5:08	6:13
5	0:30	0:15	2:53	3:17	0:35	2:00	1:00	4:23	4:28	1:20	2:30	1:40	4:53	5:08	2:05	2:45	2:15	5:08	5:43	3:05	2:45	5:08	6:13
00	0:30	0:15	2:53	3:17	0:00	2:00	1:00	4:23	4:28	0:45	2:30	1:40	4:53	5:08	1:30	2:45	2:15	5:08	5:43	2:30	2:45	5:08	6:13
22	0:30	0:15	2:53	3:17	0:22	2:00	1:00	4:23	4:28	1:07	2:30	1:40	4:53	5:08	1:52	2:45	2:15	5:08	5:43	2:52	2:45	5:08	6:13
45	0:30	0:15	2:53	3:17	0:45	2:00	1:00	4:23	4:28	1:30	2:30	1:40	4:53	5:08	2:15	2:45	2:15	5:08	5:43	3:15	2:45	5:08	6:13
					0:45	2:00	1:00	3:20	3:42	1:30	2:30	1:40	3:50	4:22	2:15	2:45	2:15	4:05	4:57	3:15	2:45	4:05	5:27
					1:25	2:00	1:00	3:26	3:47	2:10	2:30	1:40	3:56	4:27	2:55	2:45	2:15	4:11	5:02	3:55	2:45	4:11	5:32
					2:05	2:00	1:00	3:37	3:55	2:50	2:30	1:40	4:07	4:35	3:35	2:45	2:15	4:22	5:10	4:35	2:45	4:22	5:40
					2:45	2:00	1:00	4:23	4:28	3:30	2:30	1:40	4:53	5:08	4:15	2:45	2:15	5:08	5:43	5:15	2:45	5:08	6:13

TY TION TE AT PLUS IN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)		MSS ARRIVES AT SAFETY INSP. CONST DIST. AT SCRUB PLUS (HR:MIN)		SAFETY INSPECTION COMPLETE AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)		MSS ARRIVES AT SAFETY INSP. CONST. DIST. AT SCRUB PLUS (HR:MIN)		SAFETY INSPECTION COMPLETE AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)		MSS ARRIVES AT SAFETY INSP. CONST. DIST. AT SCRUB PLUS (HR:MIN)		SAFETY INSPECTION COMPLETE AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)		MSS ARRIVES AT SAFETY INSP. CONST. DIST. AT SCRUB PLUS (HR:MIN)		SAFETY INSPECTION COMPLETE AT SCRUB PLUS (HR:MIN)	MSS READY TO TRAVEL AT SCRUB PLUS (HR:MIN)	MSS ARRIVES AT SAFETY INSP. CONST. DIST.AT SCRUB PLUS (HR:MIN)	
	PAD A	PAD B	PAD A	PAD B		PAD A	PAD B	PAD A	PAD B		PAD A	PAD B	PAD A	PAD B		PAD A	PAD B	PAD A	PAD B		PADS A&B	PAD A	PAD B
5	0:30	0:15	2:41	2:51	3:45	2:00	1:00	4:11	4:15	4:30	2:30	1:40	4:41	4:55	5:15	2:45	2:15	4:56	5:30	6:15	2:45	4:56	6:00

-5 OF FIGURES 9 & 10

11

2

A. MSS TRANSFERS BETWEEN PAD AND PARKSITE

PAD A TO PARKSITE	3 HOURS 30 MINUTES
PARKSITE TO PAD A	3 HOURS 15 MINUTES
PAD B TO PARKSITE	4 HOURS 30 MINUTES
PARKSITE TO PAD B	4 HOURS 15 MINUTES
RETURN TIME AFTER STOPPING MSS IN TRANSIT TOWARD PARKSITE	RETURN TIME EQUAL TO TRAVEL TIME[1]

B. PARKSITE OPERATIONS

SECURING MSS & C/T AT PARKSITE	2 HOURS 30 MINUTES
PREPARING MSS & C/T AT PARKSITE	2 HOURS 15 MINUTES

C. PAD OPERATIONS

LAY AND SOAP PLYWOOD	2 HOURS[2]
REMOVE PLYWOOD	1 HOUR 15 MINUTES[3]

D. MSS PLATFORM OPERATIONS

	PREP TO OPEN OR CLOSE[4]	OPEN OR CLOSE TIMES	TOTAL
#1	45 MINUTES	15 MINUTES	60 MINUTES
#2	75 MINUTES	15 MINUTES	90 MINUTES
#3	75 MINUTES	15 MINUTES	90 MINUTES
#4	90 MINUTES	30 MINUTES	120 MINUTES
#5	45 MINUTES	15 MINUTES	60 MINUTES

E. ESP/LLP TRANSPORTER MOVES BETWEEN PAD AND LAUNCH POSITION (600-FT POINT)

PREP TO MOVE/SECURING[5]	MOVE TO OR FROM PAD	TOTAL
30 MINUTES	30 MINUTES	60 MINUTES

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[1] DETERMINED AS FOLLOWS: REQUIRES 30 MINUTES LESS TO TRAVEL UP RAMP BUT TAKES 15 MINUTES LONGER TO POSITION THE MSS OVER THE MOUNTS; THE OTHER 15 MINUTES IS CONSUMED IN "TURNING THE MSS TRANSFER OPERATION AROUND."

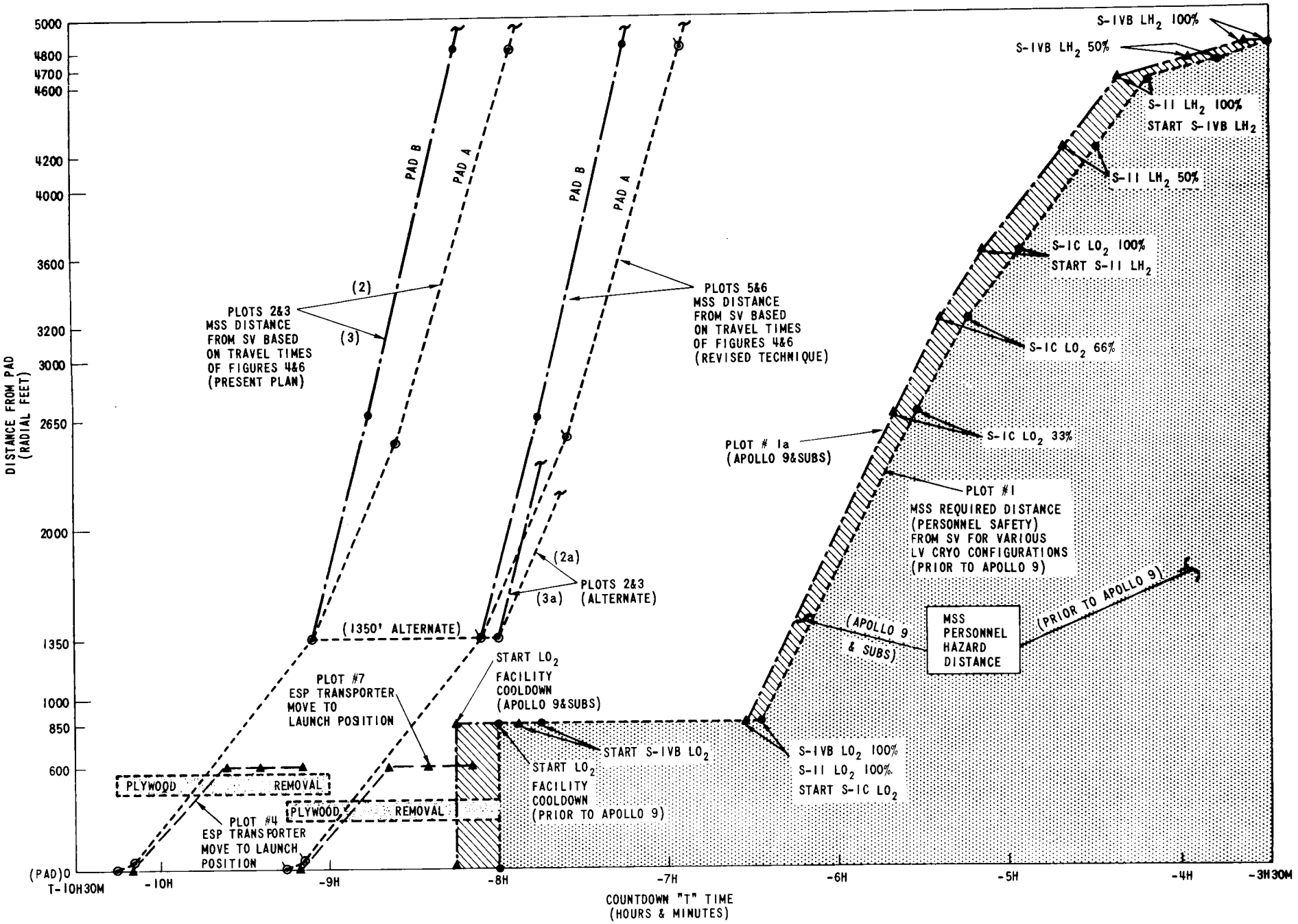
[2] MSS MOVE IS ACCOMPLISHED IN PARALLEL; MSS ARRIVES OVER MOUNTS AND IS READY FOR JACKDOWN AT THE END OF THE 2 HOURS.

[3] TRUCK WITH PLYWOOD EXITS THE PAD GATE AT END OF THE 1 HOUR 15 MINUTES.

[4] ASSUMES PLATFORM COMPLETELY TURNED OVER TO THE SUPPORT GROUP FOR PREPARATION

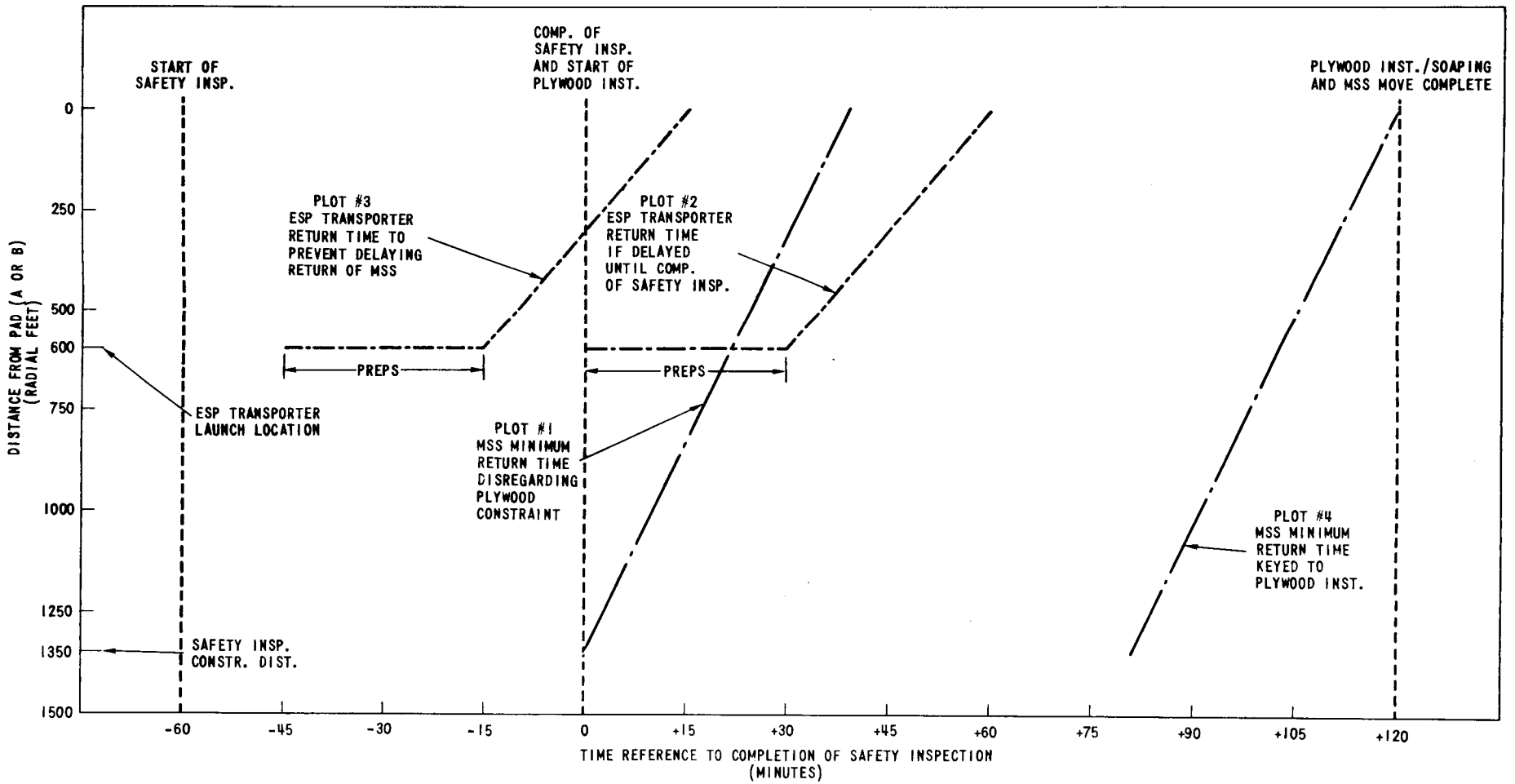
[5] PREPARATIONS REQUIRE 30 MINUTES; ALTHOUGH LV OCPS PRESENTLY ALLOW OVER AN HOUR FOR SECURING, IT IS ASSUMED FOR THIS STUDY THAT SECURING CAN BE DONE IN 30 MINUTES IF THE BENEFITS WARRANT EXPEDIENCY

AGREED UPON OPERATIONAL TIMELINES FOR MSS RELATED ACTIVITIES
FIGURE NO. 12



INFLUENCE OF LV CRYO DISTANCE CONSTRAINT (PERSONNEL SAFETY) ON MSS & ESP TRANSPORTER TRANSFERS DURING LAUNCH COUNTDOWN

FIGURE NO. 13



INFLUENCE OF PLYWOOD INSTALLATION ON ESP TRANSPORTER AND MSS RETURNS DURING SCRUB TURNAROUND

FIGURE NO. 14

APPENDIX I

CURRENT MSS DATA

This appendix is devoted to examination, explanation, and analysis of data presented in the 14 figures of this study. The 14 figures are:

FIGURE NO.	
1	LC-39 CRAWLER TRANSPORTER GROUND TRACK
2	AS-504 AND SUBS LAUNCH COUNTDOWN (MSS RELATED FUNCTIONS)
3	AS-504 AND SUBS SCRUB-TURNAROUND PRE-REQUISITES (MSS RELATED)
4	MSS TRANSFER BETWEEN PAD A AND PARKSITE
5	MSS REQUIRED DISTANCES (PERSONNEL SAFETY) FROM PAD A FOR HAZARDOUS LV PROPELLANT CONFIGURATIONS
6	MSS TRANSFER BETWEEN PAD B AND PARKSITE
7	MSS REQUIRED DISTANCES (PERSONNEL SAFETY) FROM PAD B FOR HAZARDOUS LV PROPELLANT CONFIGURATIONS
8	MSS MOVE AND RETURN TIMES BETWEEN PAD AND PARKSITE
9	MSS RETURN TIME (PAD A) VS "T" TIME OF SCRUB DECISION
10	MSS RETURN TIME (PAD B) VS "T" TIME OF SCRUB DECISION
11	DATA SHEET FOR PLOTS 1-5 OF FIGURES 9 AND 10
12	AGREED UPON OPERATIONAL TIMELINES FOR MSS RELATED ACTIVITIES
13	INFLUENCE OF LV CRYO DISTANCE CONSTRAINT (PERSONNEL SAFETY) ON MSS AND ESP TRANS-PORTER TRANSFERS DURING LAUNCH COUNTDOWN
14	INFLUENCE OF PLYWOOD INSTALLATION ON ESP TRANSPORTER AND MSS RETURNS DURING SCRUB TURNAROUND

A.I.1 Figure No. 1 - LC-39 CRAWLER TRANSPORTER GROUND TRACK

This figure shows the location of significant LC-39 facilities (launch pads, VAB, MSS parksite) and their interconnecting crawlerway. Crawlerway footages (travel distances) are shown between each pad and the parksite and also each pad and the VAB. They are drawn to scale and can be used in conjunction with the distance-time-speed chart in the upper left quadrant of the figure to calculate minimum trip times for various segments of travel.

A.I.2 Figure No. 2 - AS-504 AND SUBS LAUNCH COUNTDOWN (MSS RELATED FUNCTIONS)

This figure replaces Figure No. 2 of Reference 1. Shown are the current timelines for MSS and MSS related activities during launch countdown. Included are the timelines for Pad A and Pad B for both cases of hold; no hold time available at T-9 hours and the entire 6-hour hold available at T-9 hours.

A.I.3 Figure No. 3 - AS-503 AND SUBS SCRUB TURNAROUND PREREQUISITES (MSS RELATED)

This figure replaces Figures 3 and 7 of Reference 1. Shown are the current timelines for MSS and MSS related activities during scrub-turnaround preparations* on either Pad A or Pad B.

As can be seen, the MSS must be delayed either at the parksite or somewhere enroute to prevent arriving at the safety inspection constraint distance too early and also to prevent arrival at its launch pad position prior to completion of plywood installation/soaping.

A.I.4 Figure No. 4 - MSS TRANSFER BETWEEN PAD A AND PARKSITE

This figure is essentially identical to Figure No. 4 of Reference 1. It provides in tabular form the calculated transfer times from Pad A to the parksite and from the parksite back to Pad A. The transfer times are given for select incremental distances expressed in both radial and crawlerway travel footages.

Also included for each incremental distance is a description of the crawlerway terrain (ramp, straight-away, curve, etc.) and the accepted average C/T speed for each terrain condition.

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*Assumed scrub occurred just prior to F-1 engine ignition (≃T-9 seconds).

As noted on the figure, the calculated times do not include delays for clearance and communication events. The calculated transfer times have been demonstrated, however, by actual transfer operations and are the minimum transfer times disregarding any anomalies and/or delays.

Since minimum times are seldom realistic times to use for planning purposes, procedures, etc., agreed upon "operational timelines" have been established for various MSS related functions and are reflected in Figure No. 12.

A.I.5 Figure No. 5 - MSS REQUIRED DISTANCES (PERSONNEL SAFETY) FROM PAD A FOR HAZARDOUS LV PROPELLANT CONFIGURATIONS

This figure replaces Figure No. 5 of Reference 1. It provides in tabular form the required distances, in both radial and travel footages, that the MSS must be from Pad A for various LV cryogenic load configurations.

Also included are the nominal "T" times and "S" times each particular configuration is reached while loading and unloading, respectively, during launch countdown and scrub-turnaround operations.

Data is also provided reflecting the latest and earliest times that the MSS can depart the launch pad and parksite, respectively, without violating the distance constraint associated with each LV cryogenic load configuration.

As can be seen from the countdown data, if the MSS departs the launch pad in time to satisfy the chilldown distance constraint and continues toward the parksite at its nominal pace, all other distance constraints will automatically be satisfied as the LV is being loaded.

Similarly for the scrub-turnaround data, if the MSS departs the parksite no sooner than S+2H 58M (S-IC LO_2 @33% constraint), all other distance constraints will also be satisfied during LV unloading.

NOTE: The data in Figure No. 5 does not reflect the revised LV cryo timelines discussed in Section 5.3.

A.I.6 Figure No. 6 - MSS TRANSFER BETWEEN PAD B AND PARKSITE

This figure is similar to the data provided for Pad A in Figure No. 4. Since Pad B is 4400 feet (travel distance) further from the parksite than Pad A and also has crawlerway terrain conditions which differ from that of Pad A, different travel times can be expected.

It can be seen that the calculated transfer times from Pad B to the parksite and from the parksite to the pad are 66 minutes and 65 minutes longer, respectively, than those for Pad A. Like Pad A, the Pad B calculated transfer times have been demonstrated through actual transfer operations and are to be considered minimum times.

Agreed upon "operational timelines" for Pad B transfers are also reflected in Figure No. 12.

A.I.7 Figure No. 7 - MSS REQUIRED DISTANCES (PERSONNEL SAFETY) FROM PAD B FOR HAZARDOUS LV PROPELLANT CONFIGURATIONS

This figure is similar to the data provided for Pad A in Figure No. 5.

As in the Pad A data, if the MSS departs the launch pad in time to satisfy the chilldown distance constraint and continues toward the parksite at its nominal pace, all other distance constraints will automatically be satisfied as the LV is being loaded.

Similarly for the scrub-turnaround data, if the MSS departs the parksite no sooner than S+1H+47M (S-II LO_2 @100% constraint), all other distance constraints will also be satisfied as the LV is unloaded.

NOTE: The data in Figure No. 7 does not reflect the revised LV cryo timelines discussed in Section 5.3.

A.I.8 Figure No. 8 - MSS MOVE & RETURN TIMES BETWEEN PAD AND PARKSITE

This figure is a plot of the tabular data presented in Figures 4 and 6. Plotted are the nominal pad-to-parksite times against the corresponding nominal parksite-to-pad times. Data points are plotted for each of the select radial distances shown in Figures 4 and 6.

This figure allows rapid determination of the nominal MSS return times to either pad for scrubs occurring while the MSS is in transit toward the parksite. If the move toward the parksite is not nominal, return times can still be obtained by using the radial distance figures referenced on the respective plot points.

Although the Pad A plot is almost coincident with the lower portion of the Pad B plot, it should be noted that the radial distances vary considerably beyond the 1350-foot data point. This is due to the curve at the bottom of the ramp at Pad A.

A.I.9 Figure No. 9 - MSS RETURN TIME (PAD A) VS "T" TIME OF SCRUB DECISION

This figure replaces Figure No. 6 of Reference 1. Shown are plots of required MSS return times* vs the "T" time of the scrub decision. The various plots represent those SV and/or pad activities which constrain the return of the MSS. This is of notable importance since SC turnaround activities are dependent upon and necessarily subsequent to return of the MSS.

Four basic plots are shown. A variation for one of the plots is also shown to indicate how the planned 6-hour hold at T-9 hours affects MSS return time. A fifth plot represents how MSS return time would be affected by delaying the MSS move to the parksite as late as possible.

PLOT #1 - Plot #1 represents the required MSS return time when considering the MSS' inherent capabilities and/or constraints. This is, then, the minimum MSS return time disregarding all SV and pad constraints.

Plot #1 divides at T-9 hours in consideration of the planned 6-hour hold which may or may not be totally or partially available when that point-in-time is reached. Plot #1 (upper) indicates that if the entire 6 hours of hold is available at T-9 and the MSS move is nominal, then, the MSS move, its securing at the parksite, and clearing of MSS personnel from the parksite would all be completed during the hold. Hence, return of the MSS would require a minimum time of 6 hours 4 minutes. If none of the hold is available at T-9, the required return time would not reach the 6-hour and 4 minute value until ≈T-3 hours 28 minutes (completion of LV cryogenic servicing).

For values of hold between zero and six hours, plot #1 (upper) would start vertically upward at T-9 hours for a period of time equal to the hold and then follow a path diagonally upward to the right, parallel to plot #1 (lower), until it reached the 6 hour 4 minute return time.

PLOT #2 - Plot #2 indicates the effect of the LV cryogenic unloading distance constraint upon MSS return times. To arrive at meaningful data points which could be compared directly with plot #1, the MSS return time for

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*MSS return times include any preparation for return, the return transit time, and 30 minutes for jackdown. Platform closing times have not been included since they are dependent upon which platforms are to be closed first.

each milestone event was calculated by summing the most constraining LV unload time,* the required MSS transit time from the distance associated with the unload time, and 30 minutes for jackdown.

As can be seen from Figure No. 9, plot #2 is more constraining than plot #1 only for scrubs within the last 35 minutes of the countdown. It is, however, one of the cumulative factors which influences the constraints illustrated in plots 3 and 4.

PLOT #3 - Plot #3 indicates the effect of the post-LV cryogenic unload safety inspection upon MSS return times. Since the safety inspection requires 60 minutes** and commences with the end of LV cryogenic unload, its completion time was easily calculated from the "LV UNLOADED AT SCRUB PLUS" column in Figure No. 11.

The MSS return time for each milestone event was then calculated by summing the safety inspection completion time, the MSS transit time from the safety inspection constraint distance (assumed to be the 1350-foot point), and 30 minutes for jackdown.

It can be seen from Figure No. 9, plot #3 is more constraining than plot #1 for all scrubs subsequent to ≈T-4 hours. The safety inspection, like LV cryogenic unloading, is a cumulative factor which influences plot #4.

PLOT #4 - Plot #4 indicates the effect of the requirement to install and soap some 300 pieces of plywood (prior to MSS arrival at its pad position) upon MSS return times. The installation/soaping of plywood, which takes approximately two hours, cannot be started until the safety inspection has been completed.

The MSS return time for each milestone event was then calculated by summing the safety inspection completion time, 120 minutes for plywood installation/soaping, and 30 minutes for jackdown.

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*Determined by comparison of the "LV UNLOADED AT SCRUB PLUS" column with the "MSS ARRIVES AT MINIMUM DIST. CONST. AT SCRUB PLUS" column of Figure No. 11. The most constraining LV unload time corresponds to the MSS arrival time which is closest to it.

**A safety inspection of 45 minutes was assumed for scrubs occurring just after start of LO_2 facility chilldown.

From Figure No. 9, it can be seen that plot #4 proves to be more constraining than plots 1 and 3 for scrubs subsequent to T-10 hours 15 minutes (MSS starts moving toward the parksite and plywood removal is accomplished as the C/T moves beyond it). The maximum delay caused by the plywood occurs for scrubs between T-4 hours and T-0.

For scrubs occurring during that time-frame, the MSS can always arrive at the 1350-foot prior to completion of the safety inspection. Since the MSS minimum return time from the 1350-foot point is 2-1/2 hours (including plywood installation) and is only 68 minutes without it, the delay attributable to the plywood is 1 hour 22 minutes.

PLOT #5 - The development of a 24 hour scrub-turn-around capability on Apollo 8 (for scrubs as late as T-8 hours) pointed out the necessity to delay MSS movement toward the parksite during the built-in hold at T-9 hours. Although the capability was identified, it was not necessary to implement it on Apollo 8 since the majority of the built-in hold was used up for SM LO_2 reservicing operations.

The Apollo 8 plan would have called for the MSS to be delayed at the 1350-foot point until approximately T-8 hours 30 minutes. The difference in MSS return times can be seen by comparing two of the previously discussed plots. Plot #1 (6-hour hold at T-9) reflects an MSS return time of 6 hours 4 minutes for scrubs between T-9 hours and T-8 hours. Plot #4 indicates an MSS return time of 2 hours 30 minutes would be possible for scrubs during the same time-frame by implementing the 1350-foot delay technique.

Plot #5a reflects the MSS return time for an MSS which is delayed at the 1350-foot point until T-8 hours disregarding the plywood installation, safety inspection, and LV cryo unload constraints. This plot will be discussed in more detail in Section A.I.14.

Plot #5b reflects the MSS return time for an MSS which is delayed at its pad location until T-9 hours 15 minutes disregarding the plywood, inspection, and unload constraints. This plot will also be discussed in more detail in Section A.I.13 and A.I.14.

NOTE: The data in Figure No. 9 does not reflect the revised LV cryo timelines discussed in Section 5.3.

A.I.10 Figure No. 10 - MSS RETURN TIME (PAD B) VS "T" TIME OF SCRUB DECISION

This figure is similar to the data provided for Pad A in Figure No. 9. The only significant differences other than the 1 hour 6 minutes longer it takes to transfer the MSS between Pad B and the parksite are as follows:

1. The propellant unload distance constraint (plot #2) is never more constraining than the MSS itself (plot #1).

2. The safety inspection distance constraint (plot #3) is more constraining than the MSS itself (plot #1) only for scrubs occurring subsequent to T-30 minutes.

NOTE: The data in Figure No. 10 does not reflect the revised LV cryo timelines discussed in Section 5.3.

A.I.11 FIGURE NO. 11

This figure replaces Figure No. 8 of Reference 1. It contains the various data points used in plotting the curves of Figures 9 and 10. For each major milestone in the launch countdown (starting with MSS jacking at T-10 hours 45 minutes and continuing down through T-0), the following event times are provided for each LV cryogenic configuration having a unique distance constraint:

1. nominal time LV configuration is reached during scrub-turnaround operations

2. nominal time the MSS is ready to depart the parksite or start its return travel were it in transit at the time of scrub

3. nominal time the MSS arrives at the referenced constraint distance

4. nominal time the safety inspection is completed

5. nominal time the MSS arrives at the safety inspection constraint distance.

Comparison of the times that various constraint distances come into effect with the time that the MSS arrives at that constraint distance allows identification of which SV and/or pad operations are more constraining than the MSS itself.

NOTE: The data in Figure No. 11 does not reflect the revised LV cryo timelines discussed in Section 5.3.

A.I.12 Figure No. 12 - AGREED UPON OPERATIONAL TIMELINES FOR MSS RELATED ACTIVITIES

This figure provides in tabular form the operational timelines for MSS related activities which have been agreed upon as the standard for planning purposes. In all cases (except for the MSS move times), the timelines of Figure No. 12 were used in this study. This is due to the high degree of confidence in being able to meet the minimum timelines associated with jacking operations, platform operations, plywood installation/removal, MSS securing at the parksite, MSS preparations to leave the parksite and ESP/LLP transporter operations.

Although the MSS move timelines of Figures 4 and 6 are attainable, they are more susceptible to delays due to the extensive amount of coordination required with numerous contractor elements. Accordingly, it was deemed desirable to agree upon operational timelines which provided adequate time for accomplishing this coordination.

The MSS operational timelines of Figure No. 12 include from 6 to 26 minutes contingency time. These operational times are reflected in Figures 2 and 3. The calculated move times of Figures 4 and 6 are used for all other analysis in this study.

A.I.13 Figure No. 13 - INFLUENCE OF LV CRYO DISTANCE CONSTRAINT (PERSONNEL SAFETY) ON MSS AND ESP TRANSPORTER TRANSFERS DURING LAUNCH COUNTDOWN

This figure contains plots of MSS and ESP transporter locations vs countdown "T" time as they are being moved toward their respective launch locations. Shown are both the nominal move case and the option of holding the MSS at the 1350-foot point until T-8 hours.

Shown also are plots (previous as well as current criteria) of the required minimum distance that the MSS (for personnel safety) must be from the SV as the LV is being cryogenically serviced during the countdown.

Also included are plots reflecting the effect of a revised technique which would delay the MSS at the pad rather than at the 1350-foot point.

PLOT #1 - Plot #1 represents the minimum MSS to SV constraint distance (prior to Apollo 9) as it changes with the LV cryo configuration during the countdown. This allows personnel involved with the MSS to function inside the normally restricted blast danger area (7000-foot radius) as the MSS is being moved toward the parksite. The established MSS constraint distance begins with 850 radial feet at start of facility LO_2 line chilldown and remains unchanged (throughout S-IVB and S-II LO_2 loading) until S-IC LO_2 loading is started. The constraint distance then increases sharply as additional LO_2 and LH_2 servicing is accomplished.

PLOT #1a - Plot #1a reflects the change in LV cryo loading times effective for Apollo 9 and subs. KSC Safety has concurred with allowing LO_2 facility line cooldown to commence 15 minutes prior to completion of pad clearing. The concurrence includes a stipulation that the LUT, above the zero level, must be cleared of all personnel prior to flowing LO_2 up the tower.

PLOT #2 - Plot #2 indicates the relative position of the MSS as it is being moved (nominal timelines) toward the parksite from Pad A. As can be seen, it easily satisfies all constraint distances. This results from MSS movement being keyed to the SC A/G voice checks (ref. Section 5.1).

PLOT #3 - Plot #3 provides the Pad B counterpart for Plot #2.

PLOTS #2a and #3a - These plots indicate the effect of delaying the MSS at the 1350-foot point until T-8 hours. Although this approach is completely feasible, the benefits are somewhat limited due to the plywood installation requirement. The only benefit realized from this technique is shorter MSS return times for cases where available built-in hold time exceeds ≈75 minutes. Plot 5a of Figures 9 and 10 indicates the additional benefits available when disregarding the plywood constraint.

PLOT #4 - Plot #4 shows the location of the ESP transporter as it is moved toward its launch position (≈600 feet down the pad ramp) during the launch countdown. The movement of the ESP transporter is keyed to actual MSS movement but is moved at a slower speed than the MSS. Transfer of the transporter from the pad to its launch position requires 30 minutes with an additional 30 minutes* necessary for securing activity.

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*See note in Figure No. 12.

PLOTS #5, #6, AND #7 - Plots 5, 6, and 7 offer a revised technique for handling the MSS and ESP transporter moves from the pad during the launch countdown. Although this technique offers some very desirable and perhaps substantial benefits (discussed below), it also involves some nontechnical tradeoffs which would have to be evaluated by KSC. Therefore, the following suggestions are being offered as "food for thought" and not as recommendations.

The technique would call for the following changes:

1. elimination of the open-loop SC A/G voice checks from the T-9 hour 30 minute time-frame.

2. move all MSS related functions (breakup, jacking, transfer, etc.,) one hour closer to T-0, hence, shorten the entire launch countdown.

3. move the built-in hold point from T-9 hours to T-9 hours 15 minutes so that it is scheduled coincident with initiating MSS transfer.*

4. provide procedural capability to allow a real-time decision to retain the MSS at the pad for all or part of the unused built-in hold.

5. Start pad clearing at T-9 hours 15 minutes instead of T-9 hours (would still complete at T-8 hours).

The benefits which could be realized from this technique include:

1. topoff of time-critical CSM and LM cryogenic systems one hour closer to T-0 (countdown could actually be shortened).

2. almost immediate access to SC and LV locations throughout the built-in hold.

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*The original intent was to delay MSS transfer until T-9 hours but since LO_2 facility cooldown was recently moved 15 minutes earlier, it was necessary to consider moving the built-in hold back to coincide with the MSS transfer time.

3. reduced scrub-turnaround times for scrubs occurring in the time-frame just prior to LV cryo servicing due to reduced MSS return times.

4. reduced scrub-turnaround times since most scrub turnarounds would benefit from the one-hour reduction in countdown.

5. start of pad clearing could be returned to a full 60 minutes prior to start of LO_2 facility chilldown.

The technique is felt to be feasible based on the following rationale:

1. The SC open-loop A/G voice checks which presently require personnel participation in the CM can be eliminated from the T-9 hour 30 minute time-frame if the following statements are or can be made to be true.

   a. basic open-loop RF compatibility and capability is adequately proven during dry CDDT.

   b. existing or additional SC A/G voice checks earlier in the countdown (open-loop from the MILA USB station to MSS repeater antennas/closed-loop RF from MSS antennas to SC antenna) provide basic launch readiness of all communication modes.

   c. S-band open-loop checks can be accomplished after the MSS departs the pad at T-9 hours 15 minutes since it is not necessary to have someone in the CM during this check. (This check and/or one with the closeout or flight crews would provide final flight readiness of the S-band communications system.)

   d. late VHF checks (open-loop) with the closeout crew and/or flight crew would provide final flight readiness of the VHF communication systems.

2. The ESP transporter move timelines do not allow the ESP securing crew to exit the stipulated 7000-foot blast danger area prior to commencing LO_2 flow into the S-IVB. There would be

adequate time, however, to clear the ESP securing crew outside the pad gate by T-8 hours and have them on their way toward the parksite before LO_2 actually flows into the LV (see Figure No. 13).

Since the activity above would not expose the ESP securing crew to any greater hazard level than that presently judged acceptable for the MSS crew, it is the opinion of the author that with proper procedural control, this mode of operation could also be judged acceptable.

3. The plywood removal crew would also necessarily be inside the 7000-foot blast danger area subsequent to starting the LO_2 facility chilldown. It appears that this activity could also be judged acceptable since the plywood crew would depart the pad apron area shortly after the start of chilldown and would proceed through the pad gate prior to any LO_2 flow into the LV itself (see Figure No. 13).

A.I.14 Figure No. 14 - INFLUENCE OF PLYWOOD INSTALLATION ON ESP TRANSPORTER AND MSS RETURNS DURING SCRUB TURNAROUND

It has already been shown in Figures 9 and 10 that plywood installation causes significant delay in returning the MSS to its pad position subsequent to a scrub decision. Figure No. 14 reviews the original relationships between the ESP transporter and the MSS as well as the resultant timelines agreed upon to prevent any interference between them. Also shown is the influence of plywood installation upon both of their timelines.

A proposal for possible elimination of the plywood constraint will also be discussed relative to its effect on Figures 9, 10, and 14.

PLOT #1 - Plot #1 reflects the minimum MSS return timeline starting at the 1350-foot point at the completion of the safety inspection (disregards plywood installation).

PLOT #2 - Plot #2 indicates the nominal return timeline for the ESP transporter based on its move preps beginning after the safety inspection is complete. Notice that the MSS would necessarily be delayed since it arrives at the 600-foot point before the ESP transporter has started its travel up the ramp.

PLOT #3 - Plot #3 reflects the nominal ESP transporter move based on agreements with KSC Safety that its preps and actual movement could commence during the safety inspection. This approach ensures that the ESP transporter will have time to be completely under the SV/LUT before the MSS arrives at the top of the pad.

PLOT #4 - Plot #4 reflects the MSS return timeline as a result of delaying it for the plywood installation. Note that the ESP transporter and the MSS no longer interfere with each other's return.

Figure No. 14 as well as Figures 9 and 10 point out the delays in return of the MSS to the pad which are directly attributable to the plywood installation constraint. Since it appears impractical to consider installation of a permanent material to replace the use of plywood,* the author is of the opinion that sufficient facts now exist to warrant KSC's consideration of eliminating the plywood installation; at least for those scrub-turnaround operations where the time saved might be of utmost importance.

The facts follow:

a. The C/T steering systems are currently scheduled for modifications which will approximately double the available steering force. It is felt that this increase in steering force will be more than adequate to overcome the C/T to pad friction without the aid of plywood and/or soap. The modification, however, will inherently reduce the steering

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*Prior to the use of plywood, a spongy asphalt type material (Pro-seal) had been applied to the pad apron. This in turn was soaped to further reduce the friction between the C/T and the contact surface. It was found after the Apollo 4 launch that the surface was damaged sufficiently (by the launch environment) to warrant its removal. It was felt that refurbishment of the pad with new Pro-seal material after each launch would be impractical.

response time (how fast you can drive the steering to a desired angular position) which, if necessary, can be compensated for by reducing the C/T travel speed where extremely tight maneuvering* is required.

b. Extending the C/T guide string farther down the ramp would allow more accurate positioning of the C/T to be accomplished prior to reaching the top of the pad. This would reliably reduce the amount of maneuvering necessary during the latter part of the MSS transfer.

c. The error involved with final positioning of the C/T once it reaches the level part of the pad could be further minimized by decreasing the C/T travel speed during final positioning. This would add very little time to the total move compared to the savings which would result from elimination of the plywood.

d. Soaping the pad directly (concrete and/or grating) could possibly reduce the friction enough to warrant its consideration if the KSC assessment reveals it to be beneficial.

It is understood that the primary item of concern would be the possible damage to the pad and/or C/T should a C/T shoe get snagged on any protuberances from the pad surface during tight maneuvering. The author anticipates that a combination of (b) and (c) above could eliminate the concern over tight maneuvering.

Additionally, it might be possible to take corrective action on any pad protuberances determined to be of concern. The corrective action might take the form of removing, grinding, filling, etc., or even installing a limited number of plywood sheets over the area in question.

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*Driving the steering mechanism to a significantly different angular position while there is relatively little forward or backward motion of the C/T.

SUMMARY

THE DISCUSSIONS OF A.I.13 AND A.I.14 HAVE DEALT PRIMARILY WITH TWO NEW TECHNIQUES FOR REDUCING FURTHER THE CONSTRAINTS LEVIED ON LC-39 BY THE MSS. ALTHOUGH EACH TECHNIQUE STANDS ON ITS OWN MERITS, THE COLLECTIVE BENEFITS ARE MORE SIGNIFICANT AND CAN BEST BE VISUALIZED BY A COMPARISON OF FIVE PREVIOUSLY DISCUSSED PLOTS FROM FIGURES 9 AND 10.

PLOT #	CONSIDERATIONS	MSS TRANSFER SCHEME	MSS AVAILABILITY	MSS RETURN TIMES (MINUTES) FOR SCRUBS AT: 9:45	9:15	8:00	3:28	0	PAD
1	a) 6-HR HOLD AVAILABLE AT T-9:00 b) DISREGARDS PLYWOOD CONSTRAINT c) DISREGARDS PROPELLANT UNLOAD AND SAFETY INSPECTION CONSTRAINTS	DEPARTS PAD AT T-10:15 AND CONTINUES TOWARD PARKSITE DURING HOLD	DECREASES AT A GRADUAL RATE UNTIL T-9:00, THEN DECREASES RAPIDLY DURING THE HOLD, IS FULLY SECURED AT THE PARKSITE DURING THE HOLD	45 45	75 75	364 424	364 424	364 424	A B
1	a) NO HOLD AVAILABLE AT T-9:00 b) DISREGARDS PLYWOOD CONSTRAINT c) DISREGARDS PROPELLANT UNLOAD AND SAFETY INSPECTION CONSTRAINTS	DEPARTS PAD AT T-10:15 AND CONTINUES TOWARD PARKSITE	DECREASES AT A GRADUAL RATE THROUGHOUT THE COUNTDOWN	45 45	75 75	150 150	364 400	364 424	A B
4	a) NO HOLD AVAILABLE AT T-9:00 b) CONSIDERS PLYWOOD CONSTRAINT c) CONSIDERS PROPELLANT UNLOAD AND SAFETY INSPECTION CONSTRAINTS	DEPARTS PAD AT T-10:15 AND CONTINUES TOWARD PARKSITE	DECREASES AT A SHARPER RATE THAN PLOT #1 UNTIL T-9:00, THEN REMAINS CONSTANT UNTIL START OF PROPELLANT LOADING (T-8:00); DECREASES GRADUALLY THROUGHOUT THE REMAINDER OF THE COUNTDOWN WITH LONGER RETURN TIMES THAN PLOT #1	75 75	130 130	150 150	465 465	525 525	A B
5a	a) CONSIDERS 6-HR HOLD b) DISREGARDS PLYWOOD CONSTRAINT c) DISREGARDS PROPELLANT UNLOAD AND SAFETY INSPECTION CONSTRAINTS	DEPARTS PAD AT T-10:15 BUT IS DELAYED AT THE 1350-FOOT POINT UNTIL ≈T-8:00; (COULD INCLUDE UP TO 6 HOURS OF HOLD)*	DECREASES AT THE SAME RATE AS PLOT #1 UNTIL ≈ T-9:05; THEN REMAINS CONSTANT UNTIL ≈ T-8:00, DECREASES GRADUALLY FOR THE REMAINDER OF THE COUNT WITH SHORTER RETURN TIMES THAN PLOTS 1 & 4	45 45	75 75	75 75	340 350	364 424	A B
5b	a) CONSIDERS 6-HR HOLD b) DISREGARDS PLYWOOD CONSTRAINT c) DISREGARDS PROPELLANT UNLOAD AND SAFETY INSPECTION CONSTRAINTS	DELAY AT PAD POSITION UNTIL ≈ T-9:15 (HOLD COMPLETES AT SAME TIME)	DOES NOT START MOVE UNTIL T-9:15; DECREASES GRADUALLY FROM T-9:15 TO T-8:00, THEN DECREASES GRADUALLY AT THE SAME RATE AS PLOT 5a	0 0	30 30	75 75	340 350	364 424	A B

*WORST CASE COULD REQUIRE THE C/T TO SUPPORT THE MSS AT THE 1350-FOOT POINT FOR ≈ 7 HOURS